CERTIFICATION OF APPROVAL

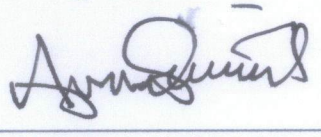
Emergency Response Planning Prototype Based on Process Safety Management for Manufacturing Industry

by

Wan Petra Anisha Binti Wan Muhaimin

A project dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons.)
(CHEMICAL ENGINEERING)

Approved by,



(Prof. Dr. Azmi Mohd. Shariff)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

WAN PETRA ANISHA BINTI WAN MUHAIMIN

ABSTRACT

The US Occupational Safety and Health Administration developed guidelines and regulations for an emergency action plan. However due to complex production processes involved in the manufacturing industry emergency planning is to be managed in a more systematic way. In order to enable planners to engage in a more systematic way of planning this research aim's to design a framework and prototype an emergency preparedness planning tool according to OSHA's guidelines and regulations. The framework is prototyped into a planning tool using Microsoft Excel, Microsoft Access and Microsoft Visio. This project work would be expected to contribute in assisting emergency planners in the manufacturing industry design better emergency plans based on OSHA's requirements. The tool is to assist planners by introducing information of the regulations in a stepwise manner for decision making compared to referring to guidelines which are arranged in categories. This concept for such a planning tool is relatively new for the manufacturing industry as OSHA's available tool doesn't use stepwise planning and is made for small businesses.

ACKNOWLEDGEMENT

First and foremost, the author would like to express her most gratitude to ALLAH S.W.T for all His blessings to make this Final Year Research Project a completion. A bunch of appreciation goes to the author's supervising lecturer, Associate Professor Dr Azmi Mohd Shariff for his assistance and guidance throughout the whole time of project ongoing. A special credit is delivered to Noor Diana binti Abdul Majid for her guidance in giving advice and sharing knowledge to author upon completing this project. Thanks are also extended to family and friends for their advice and never ending supports and lastly the author would also like to thank the industries people that have been given their cooperation to help the author completed this project.

Table of Contents

List of Figures

List of Tables

Abbreviations & Nomenclatures

OSHA	Occupational Safety and Health Administration
PSM	Process Safety Management

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The manufacturing industry is basically a production of goods for use or for sale using labor, machines, tools, and chemical or biological processing or formulation in an industrial or large scale within an economy("Manufacturing," n.d). Since people or labor are working with potentially dangerous or harmful tools and chemicals used in the process, a guideline is written in order to maintain a certain standard of safety in each factory or facility. The United States Occupational Safety and Health Administration has done this to help educate and inform manufacturers on the basic safety features that should be available while dealing and handling hazardous materials, tools and conditions.

Unfortunately an accident is inevitable and having a good response towards such unwanted event especially when it is hazardous and extremely harmful to people and the environment is extremely important. Failure to respond well when disaster strikes is detrimental towards an organization or society. History has shown time and time again the importance of being prepared for a disaster or emergency. In the manufacturing industry many cases has not gone by without further investigation or study on the effectiveness of their emergency response plan when an accident occurs. With experience and extended study, OSHA has come up with recommendation and guidelines for Emergency management systems as well. Typically emergency management activities occur at the facility where an accident might occur.

To have an emergency system, the company must design and plan such a system first. Based on past major industrial disasters studied, many did not provide sufficient planning in their emergency system.

1.2 Problem Statement

Preparing for an emergency can be overlooked easily if no proper monitoring and planning is done. Many casualties could have been avoided if there was more planning on handling emergencies in the past. (" Safety Video on Need for Chemical Emergency Preparedness, Based on Findings from a Decade of CSB Accident Investigations," 2009). The US Occupational Safety and Health Administration have done various studies and produced guidelines and regulations to ensure past mistakes in emergency management are not repeated. However with the demanding and complex environment of the manufacturing industry, this planning require a team of expert who have complete knowledge on various matters and aspects of emergency planning. . Emergency planners struggle to identify the gaps in their plans due to the complexity of their systems. A programmatic solution or tool for planning should be available in order to ensure thorough planning. (Fosher & Lathrop, 2005).

Therefore this project aims to design a framework and prototype an emergency preparedness planning tool according to OSHA's guidelines and regulations. The author understands that various companies has developed their own solutions in managing emergency. However the framework suggested would merely serve to attempt closing gaps in emergency planning according to OSHA's guidelines for end users.

1.3 Objective

The objectives of this project are as follows:

The objectives of this project is to develop a systematic and comprehensive emergency planning prototype based on OSHA regulations of CFR 1910.38 with other OSHA PSM Standard that includes a framework to build the prototype.

1.4 Scope

Emergency Planning can vary in too many ways, therefore it is essential to narrow down it's objectives and area to ensure the tool can be used for a specific type of planning.

This tool covers planning with the following elements.

Internal operational incident - consists of the systems and resources need to respond directly to the impacts of an event. These systems and resource include what are normally considered first responders (i.e. police , fire , emergency medical personnel) and manage response at the field level.

Facility emergency procedures and location management emergency response plan.- consist of written plans for the facility that covers emergency evacuation procedures, containment procedures and fire safety elements.

1.5 The Relevancy of the Project

The project is useful for the industry as it is a tool in providing necessary information in a programmatic way for emergency planning. It is to be designed in accordance to US OSHA's guidelines on emergency preparedness for the manufacturing industry. Therefore it would be relevant to users who are interested in following the guidelines to ensure the completeness of their emergency plans.

1.6 Feasibility of Project

With the given timeframe of approximately 6 months, the project wa implemented to it's best potential.

The main source of information which is OSHA's guidelines is readily available online and in books. The tools used for building the framework and designing the programming guidelines such as Microsoft Excel or Microsoft Access are also easily accessed.

CHAPTER 2

LITERATURE REVIEW

2.1 Defining Emergency

Emergency preparedness is a well-known concept in protecting worker's safety and health. There are several Occupational Safety and Health Administration (OSHA) standards that explicitly require employers to have emergency action plans.

In response to the US's Clean Air Act Amendments (CAAA) enacted in 1990, OSHA issued the Process Safety Management (PSM) of Highly Hazardous Chemicals standard in 1992. The standard requires employers to establish a PSM program to prevent major chemical workplaces emergencies and to implement an emergency action plan. The US's OSHA covers the emergency management standards comprehensively under the Process Safety Management scope .They are composed of organizational and operational procedures, design guidance, audit programs, and a host of other methods.(*Principal Emergency Response and Preparedness : Requirements and Guidance*, 2004)

According to (Wallace, 1996) an incident is an unplanned event which causes or could cause under different circumstances injury, ill health or damage to the property or the environment. Whereas an emergency is a dynamic incident in which there is a continuing potential for major injury, ill health or damage to property, the process or the environment. He also stated , there are 5 types of emergency ;

1. Internal operational incident – fire, explosions and toxic release
2. External threat – fire, explosion or toxic release in an adjacent facility or a transport accident.
3. Natural disaster – flood, wind, lightning or earthquake
4. Civil disorder – riot, demonstration, extortion or threat.
5. Malicious damage – sabotage or arson

An emergency normally develops as shown in Figure 1 below.

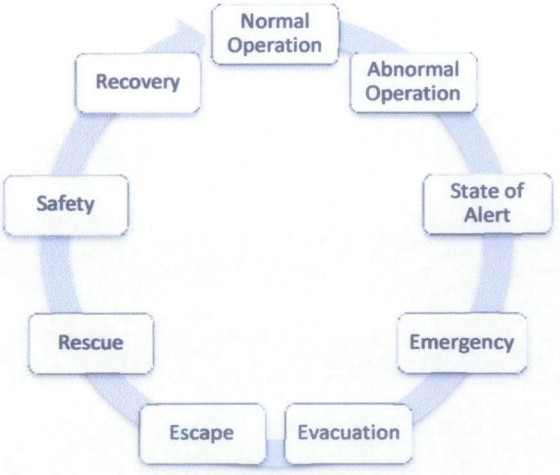


Figure 1 Typical Development of Emergency

There is a clear difference between an emergency , a major disaster and a catastrophic event. It falls into it's severity or a crisis hierarchy. This is made clear according to (Canton,2007) as illustrated in the table below;

Table 1 Hierarchy of Crisis

Level of crisis	Definition	Principal Level of Response	Response Methodology	Principal Agent
Emergency	A dangerous event that normally can be managed at the local level.	Operational - consists of the systems and resources need to respond directly to the impacts of an event. These systems and resource include what are normally considered first responders (i.e. police , fire , emergency medical personnel) and manage response at the field level.	Incident Command System	Local
Major Disaster	…causes damage of sufficient severity and magnitude to warrant major disaster assistance	Tactical - manages the overall response to the event by coordinating the activities of multiple responding agencies , anticipating resource needs, and coordinating public information.	Multiagency Coordination System	Local/State

Catastrophic Event	….results in extraordinary levels of mass casualties, damage or disruption severely affecting the population, infrastructure , environment, economy, national morale, and/or government functions.	Strategic - manages the crisis by examining long-range implications of the event , determining long term goals and objectives, and establishing priorities that will guide operational response.	Crisis Management	State/Federal

According to (Canton, 2007) , a problem that frequently occurs in planning is to determine whether a process flows logically. He outlined a few advantages in a flowchart.

- It identifies potential conflicts or illogical sequences.
- It can eliminate and highlight redundancy.
- It identifies dependancies both in terms of what is needed to accomplish the process and those elements that are relying on successful completion of the process.
- The end product not only is a useful planning tool but can also be included in the plan as a graphic.

Therefore it is a good idea to incorporate the framework in a graphical flowchart where the assessment techniques assisted by the graphical and logical display of information can provide better insights in making an emergency response plan.

2.2 Industrial Case Study.

The following cases are examples of emergency response gone wrong resulting from poor or improper planning.

2.2.1 Plan on paper – Exxon Valdez Oil Spill

Exxon Valdez oil spill was one of the studied environmental tragedies in history. The spill had an impact on 1300 miles of shoreline and 40,000 people. Clean up operations would involve 10,000 workers, 1000 boats and 100 aircraft and cost Exxon an estimated $2.1 billion . Impact on wildlife was estimated a staggering 250,000 seabirds, 2800 sea otters, 300 harbor seals, 250 bald eagles , up to 22 killer whales , and billions of salmon and herring eggs killed.

Exxon was widely criticized for its slow response to cleaning up the disaster. More than 11,000 Alaska residents, along with some Exxon employees, worked throughout the region to try to restore the environment.

Prior to the spill in 1989 , Exxon's oil spill contingency plan was reviewed by Alaska Department of Environmental Conservation (ADEC) and they had given them a "conditional approval" as the assumption for 79,000 barrels of oil was unrealistic. They requested for another plan which assumed for 200,000 barrels of oil spill.

Exxon objected to the inclusion of the second scenario and that it is very unlikely. The spill that occurred on March 23,1989 involved 260,000 barrels of oil.

Even though Exxon had submitted the plan for 200,000 barrels of oil to ADEC. The systems that would provide for such a plan was not put in place.

This shows that worst case scenarios are not to be taken lightly and emergency plans should always be put into action to improve emergency preparedness in an organization. The figures below shows the scenario after the oil spill in which shows the extent of a disaster such Exxon Valdez oil spill.

2.2.2 Sandoz SA Warehouse Fire, Bale , Switzerland

On November 1, 1986 a fire broke out at a Sandoz storehouse which contains about 1350 tonnes of at least 90 different chemicals. Flames were shooting from the roof when the fire was first noticed while steel drums of chemicals exploded like bombs under the high temperature.

Most of the chemicals were destroyed in the fire however a large amount was introduced to the atmosphere. A significant amount was also mixed with around 10 to 14 thousand cubic metres of water which flowed to the Rhine River. The water treatment plant could only contain 50m3 of water.

The exact mass of chemical entering the Rhine has been estimated to be about 13 to 30 tonnes. On top of that the soil was also contaminated to a depth of 14m and more than 10,000 m2 of earth had to be dug up at various depths and incinerated.

Prior to the fire, consideration was not given to the potential water pollution. Depending on the local arrangement, it may be necessary to provide specific firefighting water containment area.

According to (Atherton & Gil, 2008) the decision on what to do when hazardous materials are involved in a fire may be very complex. Once the fire has started but there is no adequate water catchment area would only provide two solutions. First, simply pour in water to put out the fire thus contaminating the surrounding area. Another is a controlled burn , without contaminated firewater however a longer term chronic pollution of land and water , due to the emission of contaminants from the smoke.

Therefore , it is important to agree on tactical response long before and incident with all parties that will respond.

2.2.3 Piper Alpha Platform, UK , North Sea, July 6, 1988

On July 6 1988, the Piper Alpha offshore platform , owned by Occidental Petroleum in the UK sector of the North Sea exploded and set off a chain of fires and explosion. It resulted into 167 lives lost and a near total destruction of the platform. Sixty one crew survived by jumping into the water to be rescued by boat.

The platform consisted of a drilling derrick at one end, a processing area in the centre , and living accommodation for its crew on the opposite end, a processing area in the centre . The crew began to congregate in the platform's living accommodation area , which was the farthest from the blaze and seemed the least dangerous , awaiting helicopters from landing. The accommodation was not smoke-proof and , due to lack of training , people repeatedly opened and shut doors allowing smoke to enter. Some crew member decided that the only way to survive would be to leave the accommodation immediately. However , they found that all routes to lifeboats were blocked by smoke and flames and , in the lack of any other instructions, they jumped into the sea hoping to be rescued by boat. Sixty-one men survived by jumping. Most of the 167 who died were overcome by carbon monoxide and smoke in the accommodation area.

The workers on the platform were not adequately trained in emergency procedures, and management was not trained to provide good leadership. Evacuation drills were performed but not every week as required by regulations . A full drill had not taken in over three years. The problem with safety training was not a lack of training guidelines; the guidelines were just not applied.

2.2.4 Methyl Isocyanate Release , Bhopal, India , Dec 3,1984

Methyl Isocyanate is an extremely toxic chemical that is commonly used as an intermediate in pesticide production. Short-term exposure may cause death or serious respiratory or reproductive health effects. As a liquid it is a little lighter than water. MIC vapours are twice as heavy as air, with the result that when it escapes into the atmosphere it remains close to the ground. It has the ability to react exothermically with many substances : water , acids , metals and the small deposits of corrosive materials that accumulate in pipes , tanks and valves.

On the night of December 2 , 1984 a large release of MIC vapour occurred. The weather was cool and calm. Workers first detected the leak about 11.30pm at night when they began to experience a burning sensation in their eyes. They informed their supervisors who failed to take immediate action. Over a period of two hours about 40 tons of Methy Isocyanate (MIC) , poured out of the plant , forming a low cloud, which spread downwind across the plant and into the neighbouring community.

The emergency response from the company to the incident and from the local authority suggests that the emergency plan was ineffective . ***During the emergency operators hesitated when to use the siren system.*** No information was available to outside responders regarding the hazardous nature of MIC and what medical actions should be taken.

2.3 Emergency Response Plan Review.

OSHA has outlined an Emergency Action Plan checklist ("Emergency Action Plan Checklist,") that includes the basic requirements on what should be included in such a plan. An Emergency Response Plan of a Nitrogen based product manufacturing facility (*APACHE Nitrogen Products Inc Emergency Response Plan*, 2007) was reviewed against the checklist to identify gaps between the facility's plan and what is outlined by OSHA.

The full emergency action plan checklist is included in the Appendix ii

The following are several identified elements that are not included in the plan.

2.3.1 General Issues

The plan did not outline possible internal sources of emergencies that could disrupt the workplace. A hazard assessment was not included to show identification of physical and chemical hazards that might cause an emergency.

The plan does not identify how or where personal information on employees can be obtained. It could be important to have ready access important personal information about employees for example, the home telephone numbers , the names and telephone numbers of their next of kin and medical information.

2.3.2 Evacuation Policy and Procedures.

The plan did not specify the conditions under which an evacuation would be necessary. Identification of the different types of situations that will require an evacuation of the workplace which might include fire, earthquake or chemical spill. The extent of evacuation should also be specified as different types of hazards should be managed differently.

The plan does not also include procedures to assist people who are with disabilities. An allocation of a manageable amount of people under one supervisor should be available at all times.

The plan does not identify more than one assembly area and a method of accounting for all employees. Confusion in assembly areas and inaccurate counting procedures can be time consuming.

2.3.3 Employee Training and Drills.

The plan does not show how and when employees will be trained for emergencies. The plan does not show how and when retraining will be conducted. The plan does not address how often drills will be conducted.

Many basic requirement that has been outlined by OSHA has not been fulfilled by the plan. Therefore this shows a gap between the regulations implemented by OSHA and the planning that has been done by companies.

2.4 Current OSHA Emergency Planning Tool.

Uncertainty about the quality and appropriateness of their plans are often expressed by emergency managers and would appreciate guidance on what the planning process is intended to achieve. To have an instrument that enables them to sanction and ratify local emergency plans, or alternatively demand improvements in them would be useful (Alexandar,2005).

OSHA standards are rules that describe the methods employers are legally required to follow to protect their workers from hazards. Before OSHA can issue a standard, it must go through a very extensive and lengthy process that includes substantial public engagement, notice and comment The agency must show that a significant risk to workers exists and that there are feasible measures employers can take to protect their workers ("At-a-glance OSHA,2011).

The OSHA's Emergency Planning Tool is designed to help small, low-hazard service or retail businesses write and implement an emergency action plan, and comply with OSHA's emergency standards. However , businesses that deal with hazardous or that are subject to the provisions of the Process Safety Management of Highly Hazardous Chemicals, Hazardous Waste Operations, or Grain Handling standards may also need to develop an emergency action plan in compliance with 29 CFR 1910.38(a). These businesses are beyond the scope of the tool.("Evacuation Plans and Procedures eTool,").

The main feature of this tool is it simplifies emergency planning by allowing users to include their plans in a form and it will not take more than 15 minutes to complete. However the tool does not save the information for the users and would just generate a report for the user to save as a document for their own use. Figure 2 and 3 shows the main interface of the tool by OSHA.

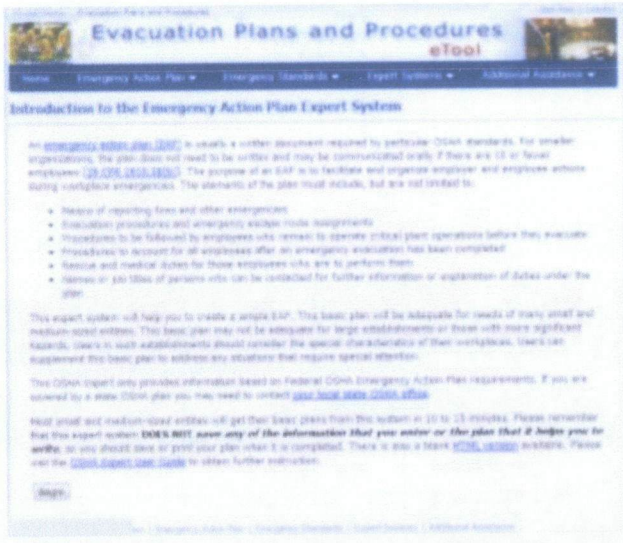


Figure 2 Main Interface of OSHA Evacuation Plans and Procedure E-Tool

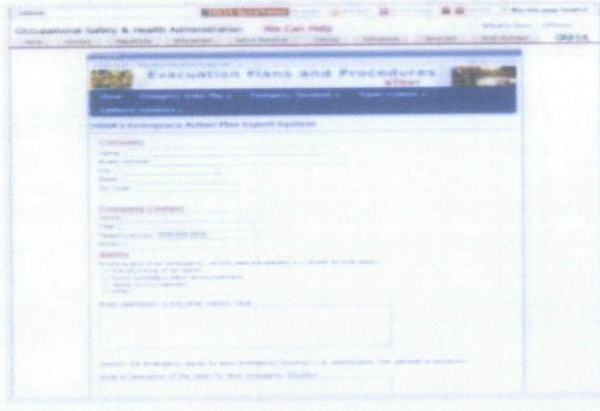


Figure 3 Form Interface of OSHA Evacuation Plans and Procedure E-Tool

There are several other emergency management tools available in the market. However these tools do not use OSHA's regulations as a basis. They are developed mostly for the public health and safety sector and are meant to be used by state or government responders. Therefore the scope of those tools does not apply for comparison with the prototype proposed as the users are different.

For example, Oak Ridge Associated Universities developed Exercise Builder , a tool that helps personnel who are responsible for developing drills and exercise ("*Emergency Preparedness at Nuclear Plants*", 2010) Although this tools assist in emergency management however it covers only one part of emergency planning , which is training. Most of the tools that can be found in the market are designed in this manner, which is highly specific and specialized. However a simple, more robust tool

to assist in emergency planning and specifically by guiding the users using OSHA's guidelines are yet to be available.

According to the literature review conducted, it can be concluded that emergency planners would benefit from a systematic tool that enables them to identify the gaps in their plans. Based on past disasters, failure to respond well is usually related to gaps in the plan or inadequate planning. However there are no current available tool that makes gap identification possible using OSHA's regulations as a basis. This shows that there is an opportunity to further explore solutions for this problem.

CHAPTER 3

METHODOLOGY

3.1 Procedure

The project began with information gathering. The requirements of emergency planning from OSHA regulations were taken from their website , www.osha.gov. OSHA has documented various guidelines on emergency planning, from Hazardous Materials response to Fire response.

Once all the information regarding emergency planning regulations are collected. The data is filtered to as per determined scope for the tool , this is because the tool could lose it's impact if the scope is too large with very general steps in planning. With the gathered required information, the emergency response framework is then systematically arranged in the form of graphical flowchart using Microsoft Visio.

The basic prototype for the emergency tool was then developed according to the flowchart using Microsoft Excel or Access. A database of useful information such as the regulations and step by step instruction for planners was constructed. Once done the complete logical flow was tested in the field which in this research the Carbon Dioxide Pilot Plant at Universiti Teknologi PETRONAS. After the case study , the tool will be reviewed for it's implementation

Information on the tools usefulness and robustness was then analyzed and interpreted. With the analyzed feedback, proper adjustments was made to the framework. The framework and programming instructions was then finalized for development of emergency planning tool application for the manufacturing industry.

A Gantt Chart on the time management done while working on this research was also constructed. The chart can be found in Appendix i.

The tools used in this research are Microsoft Access and Microsoft Visio. Microsoft Visio is a streamlined vector graphic diagramming tool for business and professional use. With Microsoft Visio, users will be able to create and share a variety of diagrams, organizational charts, flowcharts, floor plans and even network maps. Users can choose from a wide variety of templates to help you get started, modifying as easily as you go thanks to an intuitive ribbon interface and drag & drop capabilities.

Microsoft Access on the other hand enables users to create tables, queries, forms and reports, and connect them together with macros. Advanced users can use VBA to write rich solutions with advanced data manipulation and user control. Access also has report creation features that can work with any data source that Access can "access".

CHAPTER 4

RESULTS

4.1 Framework Development

A Framework of Emergency Action Plan was constructed as a preliminary phase before designing the prototype. It acts as a guide to construct the model when prototyping. The information gathered was placed in a logical flow of steps according to several OSHA Standards.

The Standards involved were.

a) CFR 1910.38 : Emergency action plans.

The emergency action plan starts with the requirement of whether or not a written plan is to be available for employees. If there is more than 10 employees then a written plan is required or else the plan can be communicated orally. There are several procedures that needs to outlined in an emergency plan. The framework describes that procedures in reporting a fire or other emergencies should be established. OSHA has not specifically recommended any guideline for this however an alarm system would normally be applicable. Another requirement would be to ensure that emergency evacuation procedures are also made available by the employer. The specific guideline to construct this can be found in CFR 1910.36. This guideline details the appropriate design and construction of exit routes and the maintenance, safeguards and operational features of exit routes.

Next is to ensure that if there are employees who do not evacuate and stay for emergency response operations, clear procedures for these operations should be available as well. The detail guidelines for these operations can be found in the CFR 1910.120 Hazardous Operations of Chemical Hazard and CFR 1910.156 Fire Brigade. Both the guidelines specifies the proper protective equipment required and the training required by the responders.

After evacuation it is essential that procedures to account for all employees are to be made available as well. Besides that employees should also that employees performing medical duties have well established procedures as well. Contact information of the employees involved in the emergency preparedness and operations should be available to everyone under the supervision of the employer.

Next, if there is an employee alarm system it needs to be maintained and designed according to CFR 1910.165. The standard outlines the general requirements, installation, maintenance and testing of the employee alarm systems. Training for all the employees whether directly or indirectly involved are also required by the all of the guidelines above as per in the 1910.38 standard. Employers are also expected to review the procedures with all employees especially upon the initial assignment of the job, when the employees responsibilities in the plan change or when the plan itself is changed. Figure 4 illustrates the framework constructed.

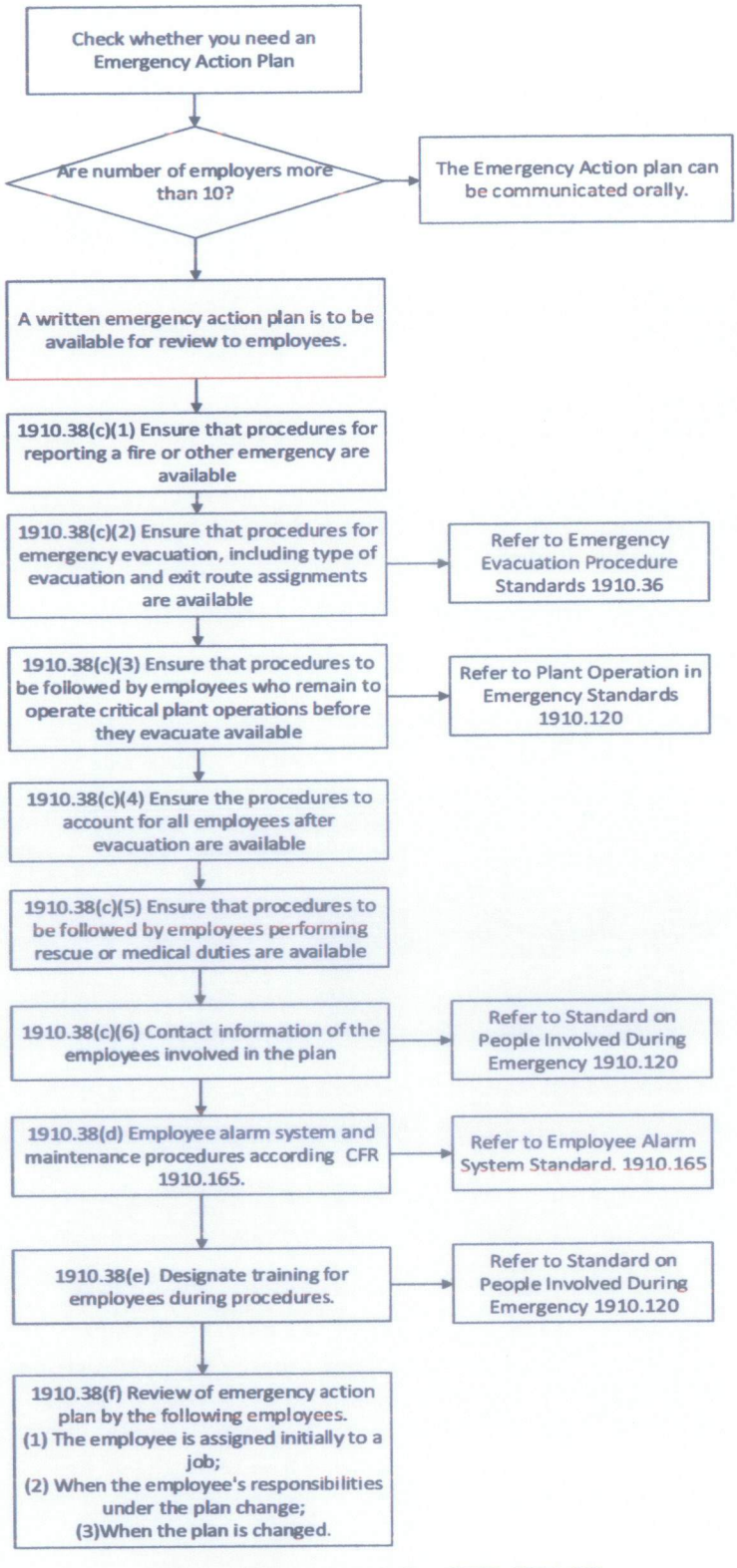


Figure 4 Framework for CFR 1910.38

b) CFR 1910.36 : Design and construction requirements for exit routes.

This standard describes the requirements for exits construction which includes the material used, number of exit routes, exit discharge, and the type of exit.It also specifies the minimum height and width of the exit door and it's minimum capacity. Figure 5 shows the framework constructed for this standard.

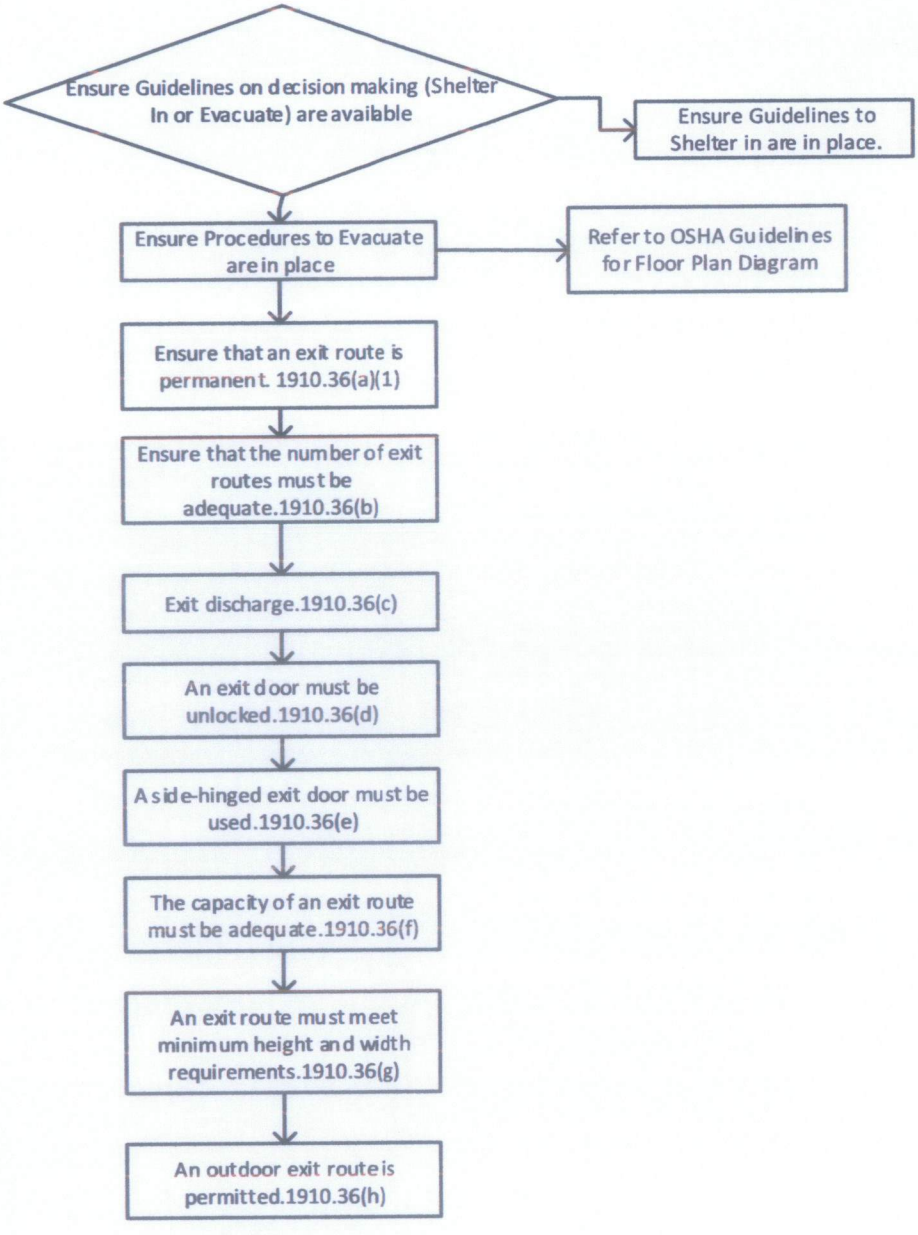


Figure 5 Framework for CFR 1910.36

c) CFR 1910.37 : Maintenance, safeguards, and operational features for exit routes.

This standard describes the requirements of the maintenance of exit routes and the safeguards and operational features involved. The standard outlines minimizing the danger of the route and ensuring that alarm systems must be operable. It also highlights appropriate marking and lighting for exit routes as well as maintaining the fire retardant properties of paints and solutions. Figure 6 shows the framework for the standard.

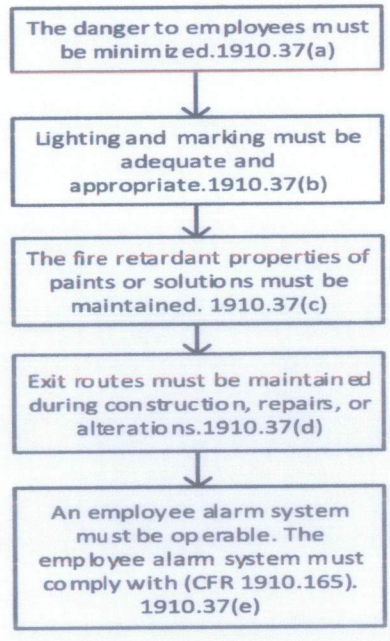


Figure 6 Framework for CFR 1910.37

d) CFR 1910.120 paragraph (q) : Emergency response program to hazardous substance releases. This standard covers employers whose employees are engaged in emergency response no matter where it occurs except that it does not cover employees engaged in operations of storage facilities and special tasks.Figure 7 illustrates the framework for the given standard by OSHA.

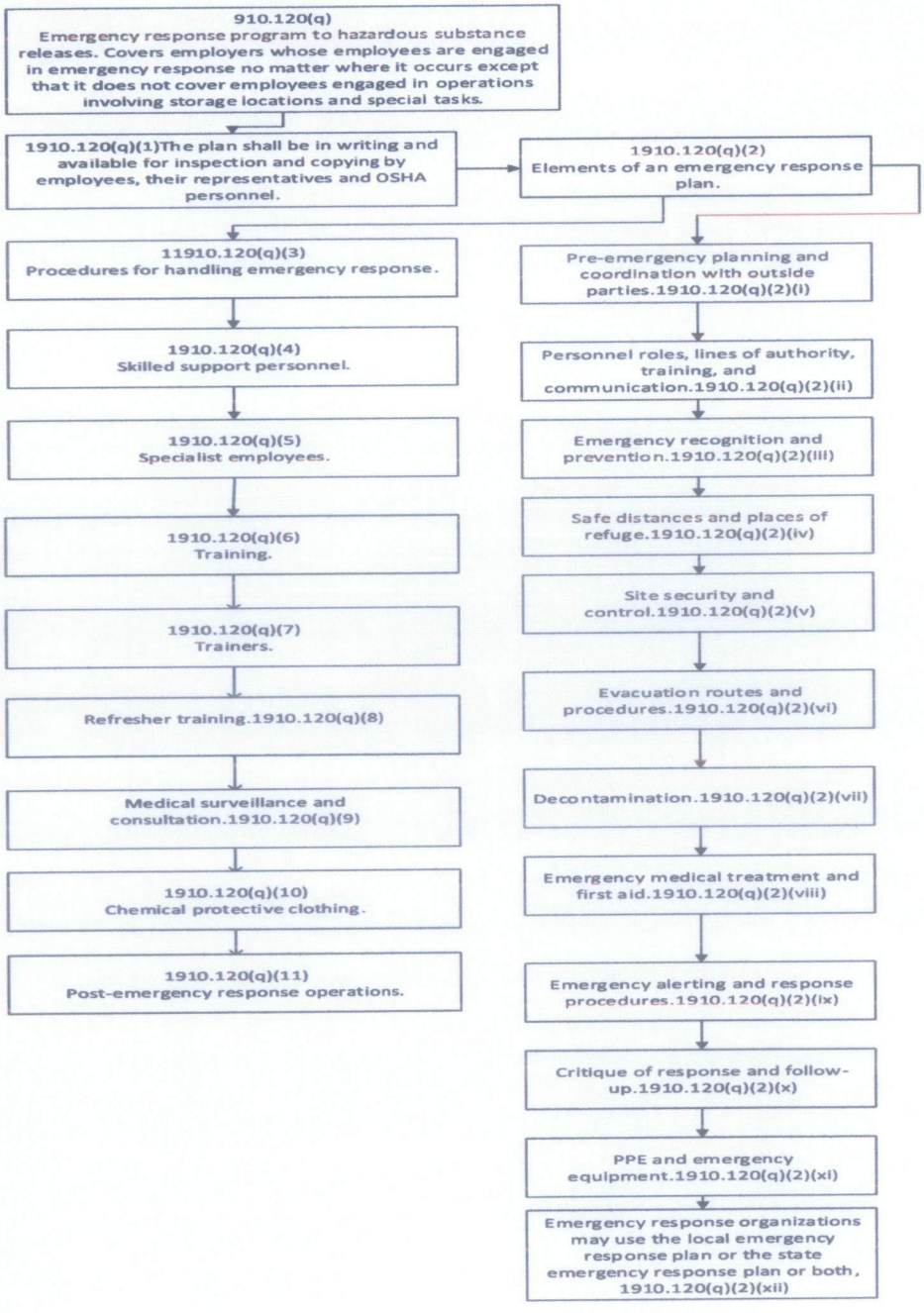


Figure 7 Framework for CFR 1910.120(q)

e) CFR 1910.165 : Employee Alarm Systems

This section applies to all emergency employee alarms installed to meet a particular OSHA standard. It describes the general requirements, installation and restoration as well as maintenance and testing. Figure 8 shows the framework constructed for Employee Alarm Systems.

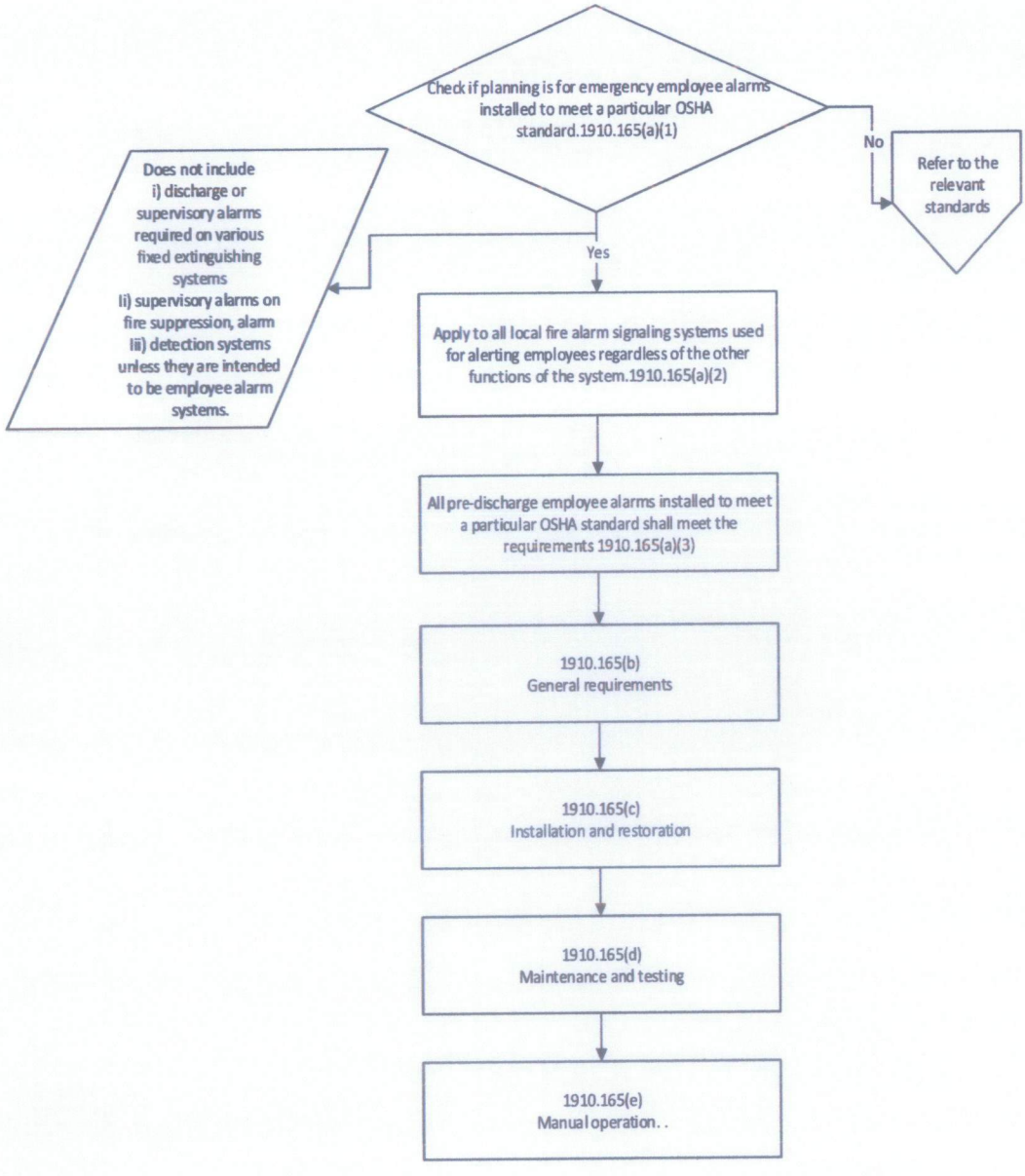


Figure 8 Framework for CFR 1910.165

4.2 Use of Plant Layout For Emergency Planning.

The plant layout is used as a basis to conduct and manage information regarding emergency planning. Since, the plant layout contains details of the particular area in the plant it is used to develop a model for emergency response planning. Plant layout contains information on the equipments and structures involved in a particular plant, the road or clearance design and various other information. Therefore, the plant layout is useful as it contains information that is essential to conduct emergency planning and could also be easily implemented in a process plant.

4.3 Prototype Development.

A prototype is then developed to illustrate the mechanism of the tool. It is designed based on the outline of the framework constructed.

4.3.1 Main Page Interface

The main page consists of all the elements in CFR 1910.38 which mandates that procedures for reporting a fire or other emergency available as outlined in 1910.38(c)(1). Procedures for emergency evacuation, including type of evacuation and exit route assignments are available as outlined in 1910.38(c)(2). Employee alarm system as outlined 1910.38(d). An employer must have and maintain an employee alarm system. The employee alarm system must use a distinctive signal for each purpose and comply with the requirements in CFR 1910.165. Training as outlined in 1910.38 (e). An employer must designate and train employees to assist in a safe and orderly evacuation of other employees. Figure 9 illustrates the main interface consisting all the elements.

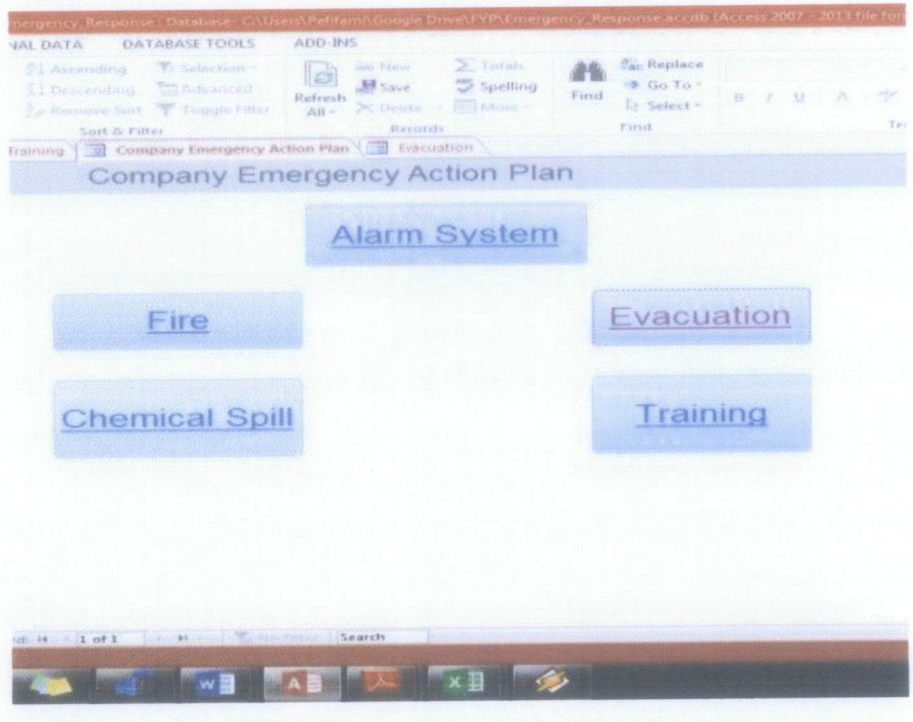


Figure 9 Main Interface of Emergency Response Planning Prototype

4.3.2 Interface of each element.

Every element shown in the main page would link to it's own individual sub pages. These pages would include the plan, guidelines in writing the plan. This is a resource for users to check whether their plans comply to OSHA's requirements. Contact information of all who are involved in the plan. To comply with 1910.38(c)(6) which mandates that the name or job title of every employee who may be contacted by employees who need more information about the plan or an explanation of their duties under the plan are to be made available. Maintenance Records of all emergency response equipment involved in the plan. 1910.39(c)(3), 1910.165(d), 1910.37(d) are all instruction in OSHA's requirements for maintenance of equipments. The interface are as illustrated in Figure 10 below. All sub pages consists of this interface to include all OSHA's requirements.

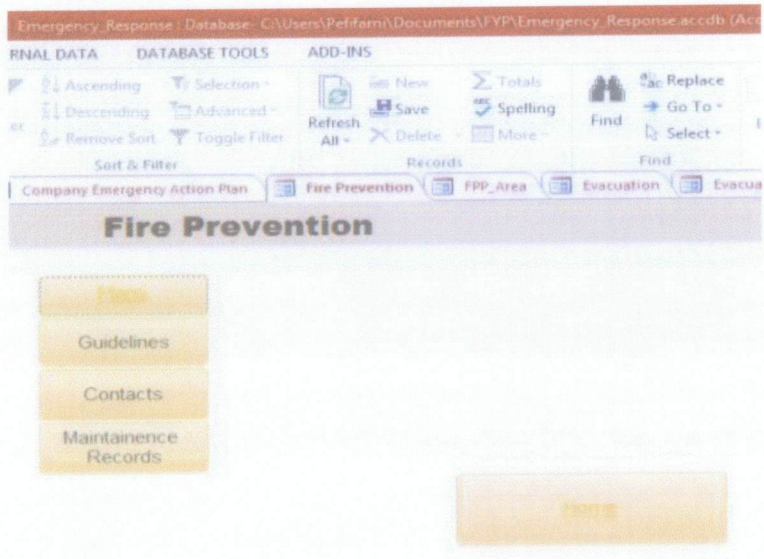


Figure 10 Sub Page for Fire Prevention Section.

4.3.3 The plans section interface

This section differ for every sub pages. However below is the interface when the "Plans" button in Fire Prevention Interface is clicked. This page would list out all the required elements in a Fire Prevention Plan according to OSHA's requirements in CFR 1910.39 *Fire Prevention Plans*. The steps taken to design the interfaces of each sub parts in the tool are similar. Therefore it is repetitive to illustrate all of them. Figure 11 shows the standard view of the interfaces that was constructed. However each parts are made to tailor their respective requirements.

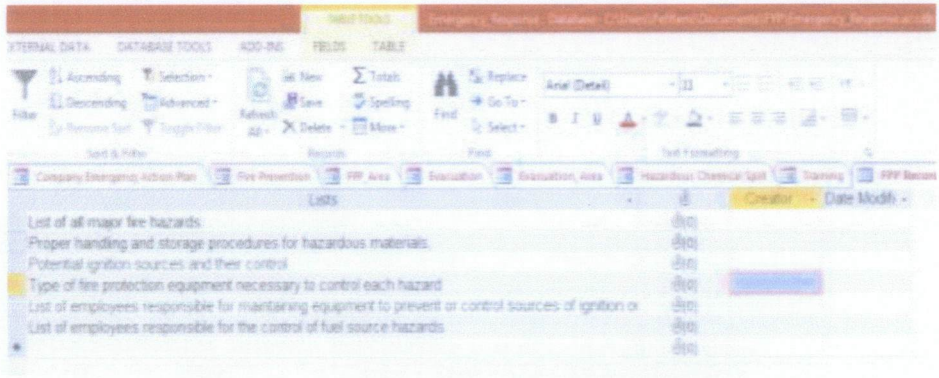


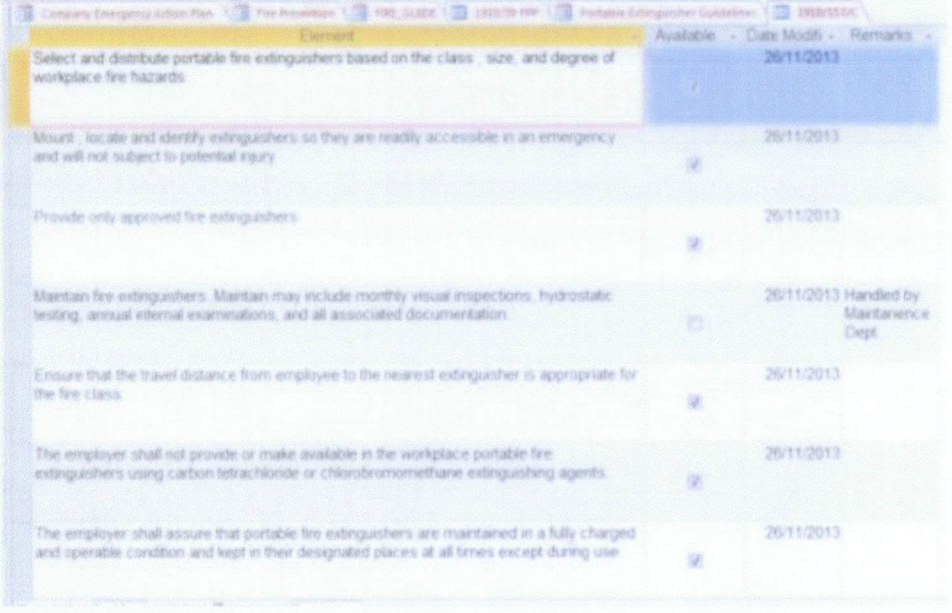
Figure 11 Plans Section for Fire Prevention Sub-page

4.4 Case Study

In order to verify this concept, the tool is to be implemented in a process plant to identify potential improvement areas and proof the validity of the model. However due to several constraints such as confidentiality and limited amount of time, the model is demonstrated via studying a Carbon Dioxide Pilot Plant emergency plan in Universiti Teknologi PETRONAS. Although the design of the tool is to allow planning by area, however the plant's scale does not require planning to be done for more than one area. The whole plant layout is used for this case study.

4.4.1 Planning Guidelines

The fixed extinguisher standard is examined at the plant. The availability of each requirement in the standard is verified by the person in charge or the emergency planner of the CO2 pilot plant. The official documentations are also provided during the examination however not shown due to confidentiality. Figure 12 shows that the every element in the standard is being met however one which is the maintanence records of the fire extinguishers which is the visual inspection, hydrostatic testing and internal examinations records are not established by the in house technician but by the maintenance department of UTP.



Element	Available	Date Modifi	Remarks
Select and distribute portable fire extinguishers based on the class , size, and degree of workplace fire hazards		26/11/2013	
Mount , locate and identify extinguishers so they are readily accessible in an emergency and will not subject to potential injury	☑	26/11/2013	
Provide only approved fire extinguishers	☑	26/11/2013	
Maintain fire extinguishers. Maintain may include monthly visual inspections, hydrostatic testing, annual internal examinations, and all associated documentation	☐	26/11/2013	Handled by Maintanence Dept
Ensure that the travel distance from employee to the nearest extinguisher is appropriate for the fire class	☑	26/11/2013	
The employer shall not provide or make available in the workplace portable fire extinguishers using carbon tetrachloride or chlorobromomethane extinguishing agents	☑	26/11/2013	
The employer shall assure that portable fire extinguishers are maintained in a fully charged and operable condition and kept in their designated places at all times except during use	☑	26/11/2013	

Figure 12 Guidelines Check for Fire Extinguishers Sub-Section in General Requirements.

Figure 13 shows that the standards in classification and selection of fire extinguishers and in accordance to the standard CFR 1910.157(d) is followed as well. However it has been make known that these selections are made by the UTP Health , Safety and Environment Department and not the employees at the pilot plant itself. This shows that there is different parties involved in the establishment of the emergency planning of the Pilot Plant. The tool can provide for these difference by including a remarks column or similar to ensure that the relevant additional information should also be recorded.

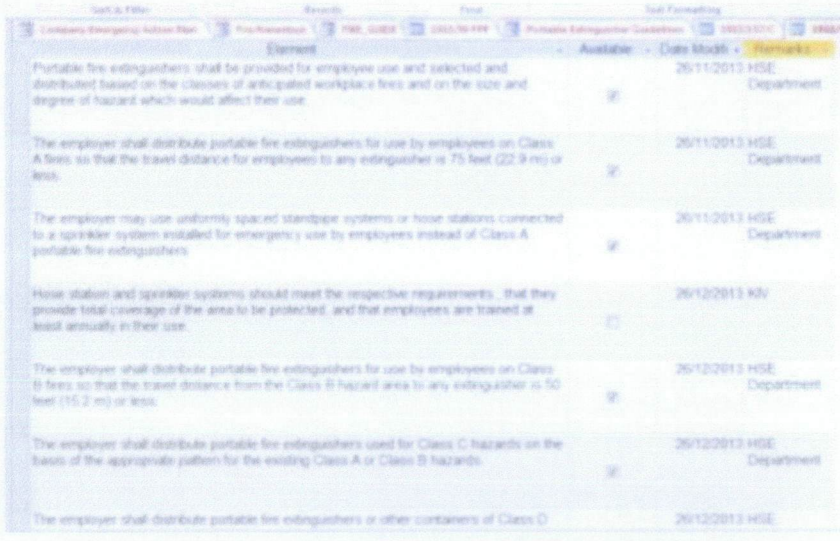


Figure 13 Guidelines Check for Fire Extinguisher Sub-Section in Selection and Distribution.

4.4.2 Plan Documentations

To demonstrate the plan documentations section the requirements of standards in evacuation is examined at the plant. One of the documentation requirements in accordance to 1910.36 is to have an emergency evacuation map available. This is available at the pilot plant and is made available to the tool by attaching the relevant documents. Figure 14 shows the evacuation plans for the CO2 pilot plant.

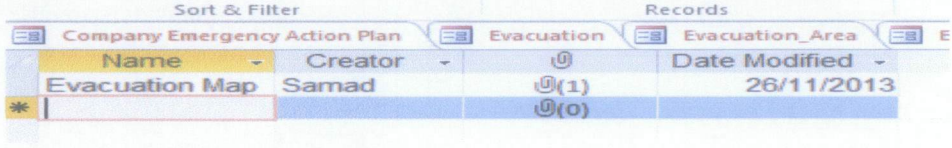


Figure 14 Plans Check for Evacuation Plans Sub- Section

Figure 15 below shows the actual evacuation map designed by the employers.

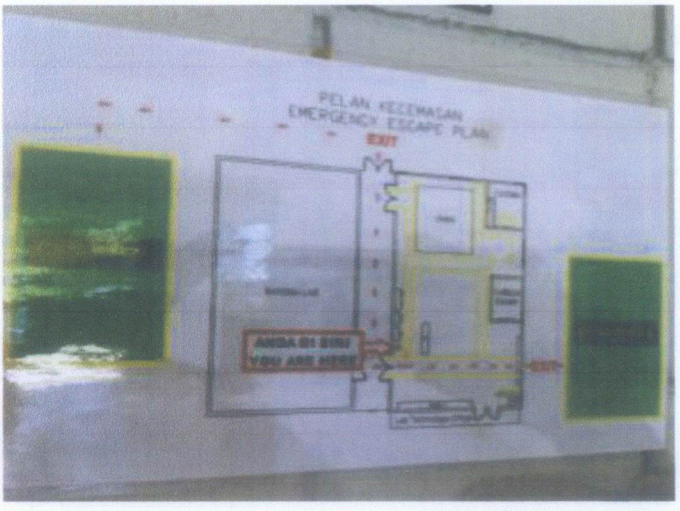


Figure 15 Evacuation Map of CO2 Pilot Plant

4.4.3 Contact Information.

CFR 1910.38 requires that all employees participating in the emergency action plan contact information should be displayed. Figure 16 shows the contact information of respective employee.

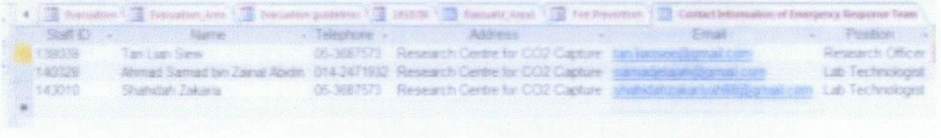


Figure 16 Contact Information Check for Contacts Section

Figure 17 shows the contact information display by the employers to contact person in charge for explanation of the emergency plan.

Figure 17 Contact Information Display at CO2 Pilot Plant.

CHAPTER 5

CONCLUSION

The present study introduces a useful technique that is beneficial for the process industries in emergency planning at a manufacturing plant. Apart from that, the concept of the tool is designed to ensure the end users are complying with the element of PSM 29 CFR 1910.38 for Emergency Action Plan. The prototype uses plant layout as the foundation for its complete data compilation since it is contains the general information on the equipments and structures involved in a particular plant, the road or clearance design and various other information. It helps the end users to track information, documents, recommendation and corrective actions of emergency planning. The system also will assist the end users to plan for each part of the requirements and help identify the gaps in order to comply with Emergency Action Plan standard. The conducted case studies show that the prototype is able to manage identify gaps in planning effectively and demonstrate step by step approach in checking the plan in accordance to OSHA requirements. Thus, by implementing this technique it could help employer to respond well in the event of an accident. The proposed technique can be used by anyone to develop the system similar prototype to ensure that the standards outlined by OSHA can be met and emergency planning can be managed effectively.

REFERENCES

Alexander, David (2005) *Towards the development of a standard in emergency planning*. Disaster Prevention and Management , 14(2), pp. 158-175

APACHE Nitrogen Products Inc Emergency Response Plan. (2007). Retrieved from http://www.apachenitro.com/.

At-A-Glance OSHA (2012). Retrieved 9 December 2013, from https://www.osha.gov?Publications/3439at-a-glance.pdf

Atherton, John, & Gil, Frederic. (2008). *Incidents That Define Process Safety*. Hoboken , New Jesey: John Wiley & Sons Inc.

Canton, Lucien G. (2007). *Emergency Management: Concepts and Strategies for Effective Programs*. Hoboken , New Jersey: John Wiley & Sons.

Emergency Action Plan Checklist. Retrieved 9 December 2013 , from https://www.osha.gov/SLTC/etools/evacuation/docs/eap_checklist.pdf

Emergency Preparedness At Nuclear Plants (2010) . Retrieved 9 December 2013, from http://www.orau.org/documents/nsem/emergency-preparedness-at-nuclear-pow er-plants.pdf

Evacuation Plans and Procedures eTool. Retrieved 27 July 2013, from https://www.osha.gov/SLTC/etools/evacuation/index.html

Fosher, Kerry, & Lathrop, Stacy. (2005). Human Practices Reveal Problems of Emergency Preparedness ; How Anthropologists Can Respond. Retrieved 29 July 2013, from http://aaanet.org/press/an/1005/Kosher_Lathrop.htm

Manufacturing. (n.d). Retrieved 9 December 2013, from http://en.wikipedia.org/wiki/Manufacturing

Principal Emergency Response and Preparedness : Requirements and Guidance. (2004). Retrieved 9 December 2013, from https://www.osha.gov/Publications/osha3122.pdf

Safety Video on Need for Chemical Emergency Preparedness, Based on Findings from a Decade of CSB Accident Investigations. (2009). US Chemical Safety Board.

Wallace, Ian G. (1996). *Developing Effective Safety Systems*. Warwickshire , UK: Institution of Chemical Engineers.

Wallace, Ian G. (1996). *Developing Effective Safety Systems*. Warwickshire , UK: Institution of Chemical Engineers.

APPENDICES

Appendix I : Emergency Action Plan Checklist

General Issues		
†	Does the plan consider all potential natural or man-made emergencies that could disrupt your workplace?	Common sources of emergencies identified in emergency action plans include - fires, explosions, floods, hurricanes, tornadoes, toxic material releases, radiological and biological accidents, civil disturbances and workplace violence.
†	Does the plan consider all potential internal sources of emergencies that could disrupt your workplace?	Conduct a hazard assessment of the workplace to identify any physical or chemical hazards that may exist and could cause an emergency.
†	Does the plan consider the impact of these internal and external emergencies on the workplace's operations and is the response tailored to the workplace?	Brainstorm worst case scenarios asking yourself what you would do and what would be the likely impact on your operation and device appropriate responses.
†	Does the plan contain a list of key personnel with contact information as well as contact information for local emergency responders, agencies and contractors?	Keep your list of key contacts current and make provisions for an emergency communications system such as a cellular phone, a portable radio unit, or other means so that contact with local law enforcement, the fire department, and others can be swift.
†	Does the plan contain the names, titles, departments, and telephone numbers of individuals to contact for additional information or an explanation of duties and responsibilities under the plan?	List names and contact information for individuals responsible for implementation of the plan.
†	Does the plan address how rescue operations will be performed?	Unless you are a large employer handling hazardous materials and processes or have employees regularly working in hazardous situations, you will probably choose to rely on local public resources, such as the fire department, who are trained, equipped, and certified to conduct rescues. Make sure any external department or agency identified in your plan is prepared to respond as outlined in your plan. Untrained individuals may endanger themselves and those they are trying to rescue.

Appendix I (Continued)

†	Does the plan address how medical assistance will be provided?	Most small employers do not have a formal internal medical program and make arrangements with medical clinics or facilities close by to handle emergency cases and provide medical and first-aid services to their employees. If an infirmary, clinic, or hospital is not close to your workplace, ensure that onsite person(s) have adequate training in first aid. The American Red Cross, some insurance providers, local safety councils, fire departments, or other resources may be able to provide this training. Treatment of a serious injury should begin within 3 to 4 minutes of the accident. Consult with a physician to order appropriate first-aid supplies for emergencies. Establish a relationship with a local ambulance service so transportation is readily available for emergencies.
†	Does the plan identify how or where personal information on employees can be obtained in an emergency?	In the event of an emergency, it could be important to have ready access to important personal information about your employees. This includes their home telephone numbers, the names and telephone numbers of their next of kin, and medical information.

Appendix I (Continued)

Evacuation Policy and Procedure		
†	Does the plan identify the conditions under which an evacuation would be necessary?	The plan should identify the different types of situations that will require an evacuation of the workplace. This might include a fire, earthquake, or chemical spill. The extent of evacuation may be different for different types of hazards.
†	Does the plan identify a clear chain of command and designate a person authorized to order an evacuation or shutdown of operations?	It is common practice to select a responsible individual to lead and coordinate your emergency plan and evacuation. It is critical that employees know who the coordinator is and understand that this person has the authority to make decisions during emergencies. The coordinator should be responsible for assessing the situation to determine whether an emergency exists requiring activation of the emergency procedures, overseeing emergency procedures, notifying and coordinating with outside emergency services, and directing shutdown of utilities or plant operations if necessary.
†	Does the plan address the types of actions expected of different employees for the various types of potential emergencies?	The plan may specify different actions for employees depending on the emergency. For example, employers may want to have employees assemble in one area of the workplace if it is threatened by a tornado or earthquake but evacuate to an exterior location during a fire.
†	Does the plan designate who, if anyone, will stay to shut down critical operations during an evacuation?	You may want to include in your plan locations where utilities (such as electrical and gas utilities) can be shut down for all or part of the facility. All individuals remaining behind to shut down critical systems or utilities must be capable of recognizing when to abandon the operation or task and evacuate themselves.
†	Does the plan outline specific evacuation routes and exits and are these posted in the workplace where they are easily accessible to all employees?	Most employers create maps from floor diagrams with arrows that designate the exit route assignments. These maps should include locations of exits, assembly points and equipment (such as fire extinguishers, first aid kits, spill kits) that may be needed in an emergency. Exit routes should be clearly marked and well lit, wide enough to accommodate the number of evacuating personnel, unobstructed and clear of debris at all times, and unlikely to expose evacuating personnel to additional hazards.
†	Does the plan address procedures for assisting people during evacuations,	Many employers designate individuals as evacuation wardens to help move employees from danger to safe areas during an emergency. Generally, one warden for every 20 employees should be adequate, and the appropriate number of

	particularly those with disabilities or who do not speak English?	wardens should be available at all times during working hours. Wardens may be responsible for checking offices and bathrooms before being the last person to exit an area as well as ensuring that fire doors are closed when exiting. Employees designated to assist in emergency evacuation procedures should be trained in the complete workplace layout and various alternative escape routes. Employees designated to assist in emergencies should be made aware of employees with special needs (who may require extra assistance during an evacuation), how to use the buddy system, and any hazardous areas to avoid during an emergency evacuation.

Appendix I : Continued

†	Does the plan identify one or more assembly areas (as necessary for different types of emergencies) where employees will gather and a method for accounting for all employees?	Accounting for all employees following an evacuation is critical. Confusion in the assembly areas can lead to delays in rescuing anyone trapped in the building, or unnecessary and dangerous search-and-rescue operations. To ensure the fastest, most accurate accounting of your employees, consider taking a head count after the evacuation. The names and last known locations of anyone not accounted for should be passed on to the official in charge.
†	Does the plan address how visitors will be assisted in evacuation and accounted for?	Some employers have all visitors and contractors sign in when entering the workplace. The hosts and/or area wardens, if established, are often tasked with assisting these individuals evacuate safely.

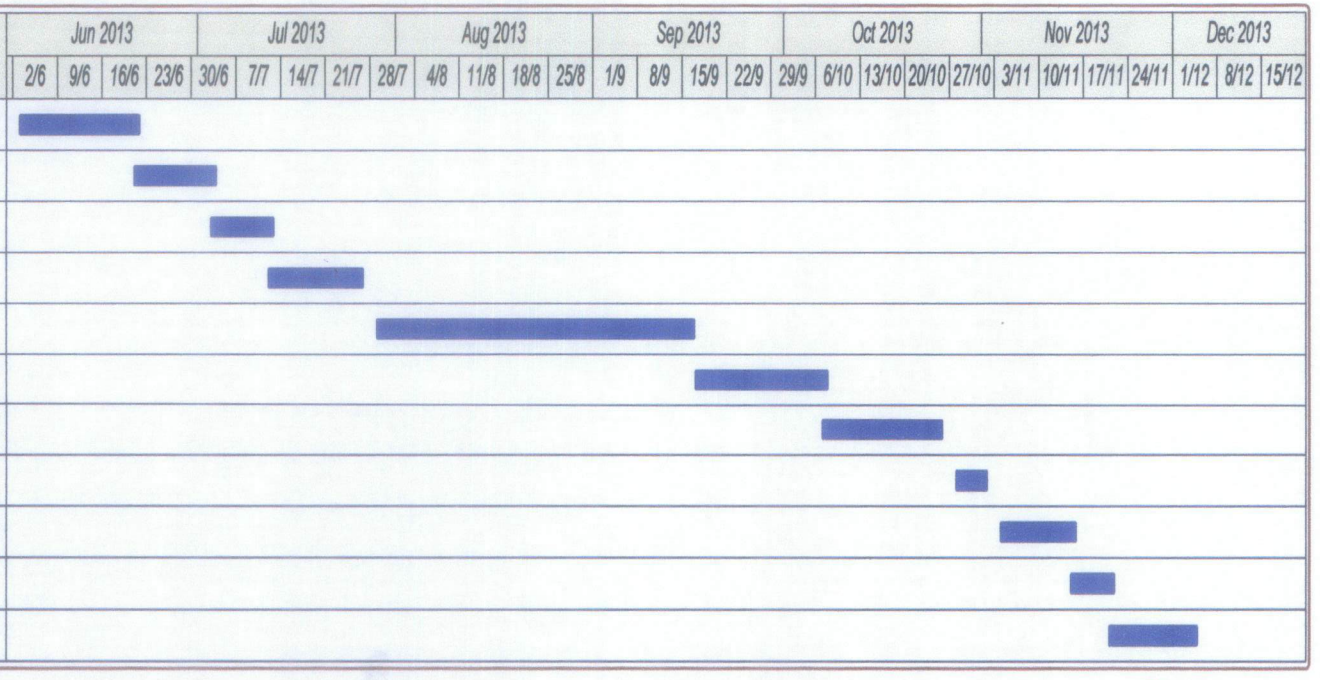
Reporting Emergencies and Alerting Employees in an Emergency		
†	Does the plan identify a preferred method for reporting fires and other emergencies?	Dialing 911 is a common method for reporting emergencies if external responders are utilized. Internal numbers may be used. Internal numbers are sometimes connected to intercom systems so that coded announcements may be made. In some cases employees are requested to activate manual pull stations or other alarm systems.
†	Does the plan describe the method to be used to alert employees, including disabled workers, to evacuate or take other action?	Make sure alarms are distinctive and recognized by all employees as a signal to evacuate the work area or perform other actions identified in your plan. Sequences of horn blows or different types of alarms (bells, horns, etc.) can be used to signal different responses or actions from employees. Consider making available an emergency communications system, such as a public address system, for broadcasting emergency information to employees. Ideally alarms will be able to be heard, seen, or otherwise perceived by everyone in the workplace including those that may be blind or deaf. Otherwise floor wardens or others must be tasked with ensuring all employees are notified. You might want to consider providing an auxiliary power supply in the event of an electrical failure.

Appendix I (Continued)

Employee Training and Drills		
†	Does the plan identify how and when employees will be trained so that they understand the types of emergencies that may occur, their responsibilities and actions as outlined in the plan?	Training should be offered employees when you develop your initial plan and when new employees are hired. Employees should be retrained when your plan changes due to a change in the layout or design of the facility, when new equipment, hazardous materials, or processes are introduced that affect evacuation routes, or when new types of hazards are introduced that require special actions. General training for your employees should address the following: • Individual roles and responsibilities; • Threats, hazards, and protective actions; • Notification, warning, and communications procedures; • Emergency response procedures; • Evacuation, shelter, and accountability procedures; • Location and use of common emergency equipment; and • Emergency shutdown procedures. You may also need to provide additional training to your employees (i.e. first-aid procedures, portable fire extinguisher use, etc.) depending on the responsibilities allocated employees in your plan.
†	Does the plan address how and when retraining will be conducted?	If training is not reinforced it will be forgotten. Consider retaining employees annually.
†	Does the plan address if and how often drills will be conducted?	Once you have reviewed your emergency action plan with your employees and everyone has had the proper training, it is a good idea to hold practice drills as often as necessary to keep employees prepared. Include outside resources such as fire and police departments when possible. After each drill, gather management and employees to evaluate the effectiveness of the drill. Identify the strengths and weaknesses of your plan and work to improve it.

Appendix II : Gantt Chart and Key Milestones

ID	Task Name	Start	Finish	Duration
1	Literature Review	3/6/2013	21/6/2013	3w
2	Extended Proposal Preparation	21/6/2013	3/7/2013	1.8w
3	Proposal Defense Preparation	3/7/2013	12/7/2013	1.6w
4	Interim Report Submission	12/7/2013	26/7/2013	2.2w
5	Data Gathering	29/7/2013	16/9/2013	7.2w
6	Framework Design	17/9/2013	7/10/2013	3w
7	Develop Programming Instructions	7/10/2013	25/10/2013	3w
8	Field Testing	28/10/2013	1/11/2013	1w
9	Readjust based on Feedback	4/11/2013	15/11/2013	2w
10	Finalizing Tool	15/11/2013	21/11/2013	1w
11	Final Dissertation Presentation	21/11/2013	4/12/2013	2w



Gantt **Chart**